André L. Vaillancourt.

An Introduction to Air Pollution and Its Control in Ontario

Ontario

Ministry of the Environment

Hon. J.A.C. Auld
Minister

Everett Biggs
Deputy Minister

AN INTRODUCTION TO AIR POLLUTION AND ITS CONTROL IN ONTARIO

Air pollution control is a matter of vital concern to us all. Each of us, on average, breathes 22,000 times a day, taking in about 35 pounds of air in the process. It is our main link with life, far exceeding our dependence on food and water. An adult might live six weeks without food, three days without water, but only minutes without air. Its quality must be protected.

What Is Air Pollution?

In simple terms, air pollution exists when certain substances are present in the atmosphere in sufficient concentrations that they adversely affect the environment.

As defined in Ontario's Air Pollution Control Act, 1967, air pollution is "... the presence in the outdoor atmosphere of any air contaminant or contaminants in quantities that may cause discomfort to or endanger the health or safety of persons, or that may cause injury or damage to property or to plant or animal life or that may interfere with visibility or the normal conduct of transport or business.

Historical Background and First Attempts at Control

Air pollution is not a new problem. It is caused by a variety of natural phenomena as well as by human activities and has been present since the earth began.

Natural air pollution results from volcanic eruptions, earthquakes, forest fires and even simple wind action. Bacteria, pollen and salt crystals (the last from the surfaces of large bodies of salt water) can be carried by wind, for example, for great distances before being deposited. Sea-water salt in fact has been found in the prairie provinces.

Man began contributing to air pollution with his first fire and he steadily continued to do so during his development through the ages of fire, copper, bronze, iron and steel down to the present age of atomic power and space travel. Even so, all but two air pollutants are still produced in far greater tonnages by natural processes than by modern

industry. Man outdoes nature only in the production of sulphur dioxide and carbon monoxide.

British recorded history shows how long air pollution has been a problem in that country.

In 1257, the smoke of Nottingham was so bad that Queen Eleanor, who was staying there while Henry III led an expedition into Wales, was compelled to move to Tutbury.

In 1306, Edward I issued a royal proclamation prohibiting the use of coal in certain furnaces. Punishment for the first offence was a fine; for the second, demolition of the furnace; for the third, execution. One such execution actually took place.

In 1661, coal smoke was so bad in London that the diarist John Evelyn, in writing about it stated, "... the weary Traveller, at many miles distance, sooner smells, than sees the City."

Initially, air polluting activities were limited to small settlements and towns and they were treated as individual smoke and odor problems because only those people living close to actual sources were affected. With the coming of the Industrial Revolution, however, the situation rapidly changed. Cities grew and air pollution incidents increased in both frequency and complexity resulting in total pollution of entire metropolitan air spaces.

In England, the smoke problem began to be attacked on a community basis in the 19th century. The first anti-smoke ordinance was adopted in 1857. In the United States, the first such law was put into force in Chicago in 1881. In Canada, a Toronto by-law was passed in 1907.

In the 20th century, the resources of science and technology began to be applied more fully to the control of municipal air pollution as greater knowledge of the nature and control of air pollution started to emerge.

In the early part of the century, control programs were designed to control visible emissions, primarily smoke. It is only in the last 20 years that legislation has been passed concerning invisible air pollution. (1) During this period, the problem has commanded the attention of professionals from many specialized disciplines -- engineering, law, public administration, economics, medicine and numerous areas of pure science.

---

(1) When the term "air pollution" is used, it is usually done so with regard to smoke pouring out of a chimney. Actually, the smoking chimney is only one source of air pollution. There are many others producing both visible and invisible contaminants. Carbon monoxide is an obvious example of invisible pollution. Another is cigarette smoke. Its gases and particles remain in the air long after disappearing from actual view.

Sources of Air Pollution

Air pollution is a major by-product of a civilization that has become dependent upon industrial technology for survival. Our age is one of complex production techniques, sophisticated forms of transportation, mass communication, rapid distribution systems for the delivery of raw materials and manufactured products, centralized energy and heat sources, intricate urban structures. All aspects are involved in the production of air pollution which results from three basic processes:

1. Combustion

2. Vaporization

3. Mechanical attrition

Combustion

The combustion of fossil fuels and waste materials for heat, steam and electrical energy is required for warmth, metal melting, motive power, food processing, incineration of waste materials, baking, tempering, curing and many other operations. The products of combustion -- smoke and gases -- comprise what are known as "contaminant plumes," the familiar trademarks of all industrial areas.

Vaporization

Vaporization, or volatilization, is a by-product of many chemical and manufacturing operations which induce physical changes in substances through the application of heat and pressure, thereby causing some component materials to vaporize into the atmosphere.

Vaporization includes the evaporation of volatile materials at normal atmospheric temperatures and pressures; fuming, as a result of induced temperatures; and decomposition of organic materials due to natural processes. Materials that evaporate at normal atmospheric temperatures and pressures include petroleum derivatives such as gasoline, fuel oil, paint and cleaning solvents.

Fuming includes both volatilization and condensation. It takes place in acid manufacturing and handling, and in metal melting operations where molten metal liquids are first volatilized to the gas state and then condensed to dusts by rapid cooling. Decomposition is associated with the handling of highly organic compounds or animal tissue with nitrogenous or sulphurous contents.

Mechanical Attrition

Mechanical attrition includes crushing, grinding, drilling, demolishing, mixing, batching, blending, sweeping, sanding, cutting, pulverizing, spraying, atomizing, etc., all of which either directly or indirectly disperse particulates in the form of dusts or mists into the atmosphere. These activities are everyday aspects of modern life and industry.

Types of Air Pollution

Air pollution consists of either one or a combination of the following physical states:

1. Aerosols and particulates (mists and dusts)

2. Organic gases

3. Inorganic gases

1. Aerosols and Particulates

The diameters of contaminant particles emitted from man-made sources vary greatly in size from 1,000 microns (the size of raindrops) to substantially less than one micron. (The micron is a microscopic unit measure equivalent to 1/1,000 of a millimetre, or 1/25,000 of an inch.) Cigarette smoke particles range in size from 0.01 to 0.5 micron. Particles smaller than 10 microns tend to remain suspended in air. Larger particles tend to settle upon available surfaces.

Aerosols are usually taken to mean particles which range in size from 10 microns to something less than 0.01 micron. Most aerosols are considered to be less than 1 micron in diameter.

Particulate matter is responsible for two basic air pollution effects:

1. Soiling, corrosion, injury to clothing, property and crops as a result of deposition.

2. Adhesion of particulate matter to respiratory tissues with possible physiological impairment or damage. Particulate matter may include toxic substances, possibly carcinogens and radioactive materials.

Aerosols tend to remain suspended permanently in the air. They are usually emitted either in aerosol form or evolve from the fracturing or decomposition of large particulates. They also form in the air from the condensation and nucleation of gaseous contaminants. They may be organic or inorganic in composition, and either liquid or solid.

The smaller the aerosols, the more they behave like a gas. Aerosols, therefore, are not as readily deposited as the particulates and may be inhaled and exhaled with air. Aerosols are also important because of their ability to reduce visibility through the process of light scattering.

2. Organic Gases

Organic gases are hydrogen-carbon compounds and their derivatives. They include all classes of hydrocarbons (olefins, paraffins and

aromatics) and the derivatives formed when hydrogen is replaced by oxygen, halogens, nitro or other substituent groups.

The principal origin of hydrocarbons is petroleum. Hydrocarbons and their derivatives are released to the atmosphere during the refining of petroleum and the transfer, storage and use of petroleum products (fuels, lubricants and solvents). They are also formed in the atmosphere due to certain photochemical reactions.

The most important source of hydrocarbon emission is the gasoline-fuelled motor vehicle, especially in heavily populated areas. The other major class of hydrocarbon contributor consists of industrial and commercial users of organic solvents. They and their counterparts in the petroleum industry account for 98% of all hydrocarbon emissions.

Hydrocarbons and their derivatives are important because of their role in the production of photochemical smog. Most reactive are the olefins (unsaturated hydrocarbons). They can react with nitrogen dioxide to produce visibility-reducing aerosols and oxidants (primarily ozone) causing plant damage and eye irritation.

Paraffins (saturated hydrocarbons) and aromatic hydrocarbons can also react with nitrogen dioxide to produce a similar variety of irritating effects. Hydrocarbon derivatives produced by photochemical reactions include aldehydes, ketones, and nitro-substituted organics that in turn react to worsen smog effects.

3. Inorganic Gases

Major inorganic gases are oxides of nitrogen, oxides of sulphur and carbon monoxide. Of less importance with regard to air pollution are ammonia, hydrogen sulphide and chlorine. Principal source of the oxides is fuel combustion --industrial, commercial and domestic for purposes of transportation, space heating and power generation.

Oxides of nitrogen: There are many oxides of nitrogen but only nitric oxide (NO) and nitrogen dioxide (NO_2) are important as air contaminants. Nitric oxide is formed when atmospheric nitrogen is oxidized during fuel combustion in automobiles, incinerators and industrial furnaces. The amounts produced are in direct proportion to fuel consumption, increasing tremendously at high temperatures.

Once in the atmosphere, nitric oxide is then able in the presence of sunlight to combine with available atmospheric oxygen to form nitrogen dioxide, one of the major ingredients, as mentioned above of photochemical smog. Oxides of nitrogen have increased in quantity lately, largely due to the greater compression ratios and engine temperatures of late model motor vehicles.

Oxides of sulphur: Only two oxides of sulphur -- sulphur dioxide (SO_2) and sulphur trioxide (SO_3) -- are classified as air contaminants. They are formed primarily during the combustion of fuels that contain sulphur (e.g., coal and oil). The amounts produced, therefore, are

direct functions of fuel sulphur content and total fuel consumption. Normally, sulphur dioxide is produced in far greater quantities than sulphur trioxide. The latter is formed only under rather unusual conditions.

Gaseous oxides of sulphur are significant because of their toxicity. They have been associated with illness arising from many severe air pollution episodes although the exact relationship, even at concentrations found in the most heavily industrialized community, is still ill-defined.

Each oxide can combine with water in the air to form toxic acid aerosols that corrode metal surfaces, fabrics and plant leaves. Sulphur dioxide, in particular, causes a characteristic type of vegetation damage whereby portions of leaves are bleached in a specific pattern. In concentrations as small as 5ppm., sulphur dioxide is irritating to the eyes and respiratory system. It is colorless with a characteristically pungent suffocating odor.

Carbon monoxide: Carbon monoxide (CO) results from the incomplete combustion of carbonaceous fuel. Automobiles are the principal source, contributing as much as 97% of the total amount in a large metropolitan area. The exhaust from an individual car is one to five per cent carbon monoxide depending upon carburetor adjustment. Although produced in enormous quantities throughout the world, carbon monoxide forms only .00001 per cent of the atmosphere. It is presumed that most of it is oxidized to carbon dioxide (CO_2).

Carbon monoxide is poisonous to man and animals. In suitable concentrations, it acts as an asphyxiant interfering with the blood's ability to carry and release oxygen. Initial symptoms are slight headache and shortness of breath. In sufficient concentrations, it is, of course, fatal.

In general, toxicologists hold that concentrations of carbon monoxide would have to exceed 500 ppm for at least one hour before a detectable effect upon human health is produced. Carbon monoxide has been detected in urban atmospheres at concentrations ranging from substantially 0 to 150 ppm. Greater concentrations have occasionally been measured in confined spaces such as tunnels and large, poorly ventilated garages. As yet, atmospheric concentrations have not been linked to fatalities.

Miscellaneous Inorganic Gases: Ammonia, hydrogen sulphide, chlorine, fluorine and fluorides are normally detectable in only trace quantities in the atmosphere but all are toxice in small to moderate concentrations. The first three have unpleasant odors.

Hydrogen sulphide can cause discoloration of certain kinds of paint. Ammonia can discolor certain fabric dyes and is corrosive to copper, brass, aluminum and zinc. Chlorine can discolor certain fabric dyes. Fluorine and fluorides, especially hydrogen fluoride, are highly toxic and corrosive. They can cause damage to vegetation, and illness and injury to humans and animals.

Effects of Air Pollution

As air pollution increases, certain effects become apparent. Visibility is reduced, vegetation is injured, property and clothing are soiled and, most vital of all, human health is affected.

Visibility Reduction

Reduction in visibility is due to the concentration of aerosols in the atmosphere. There are two basic effects:

1. Sky darkening

2. Haziness (light scattering)

Sky darkening is the physical obstruction of sky illumination due to clouds of contaminants or plumes of smoke and fumes.

Haziness is the alteration of sky illumination due to light scattering. The blue color of the sky is the result of sunlight being scattered by molecules of atmospheric gases. Similarly, the color of the sky can be altered by pollution hazes. Type and degree of alteration depends upon the size of aerosols present relative to light wave length. Aerosols 0.4 to 0.9 microns in diameter are most effective in light scattering.

Visibility reduction is an indication of pollution accumulation and its measurement is one way in which pollution intensity can be determined. Visibility records can be used to show daily, weekly, monthly and yearly variations. They reflect not only weather variations but also changes in industrial practices and the effects of pollution control procedures.

As the sky is darkened, either by normal cloud or pollution effects, the amount of available sunlight reaching the ground is reduced. As sunlight is essential to human and plant life, its obstruction due to any cause can be a serious matter if it occurs often or for prolonged periods.

Vegetation Injury

Injury to crops and trees resulting from air pollution has been clearly established. It can range from visible markings on foliage to reduced growth and yield to premature death of plant life. The ensuing visual and economic consequences can at times be disastrous. Injury to crops possessing marketable foliage such as lettuce or tobacco can result in especially high losses.

Vegetation injury often serves as a warning to man of the presence of toxicants that may also affect human health and poison foraging cattle. In addition, it can sometimes be used as an indicator of the chemical reactivity of the air.

Vegetation in Ontario suspected or known to have been injured by air pollutants include ornamental flowers, garden fruits and vegetables, stored vegetables, greenhouse chrysanthemums and roses, farm crops (white beans, tomatoes, green onions, winter wheat, oats, and corn), animal pastures and cured hay, and fruit and forest trees.

Suspected air pollutants and those ascertained as having caused vegetation injury include fluorides, sulphur dioxide, oxidants, boron, lead chlorine, hydrogen chloride, liquefied gases, chromium, nickel, salt spray, urea, nitrogen dioxide, ammonia, cement dust, magnesium-lime dust, flyash and detergents. Any pollutant that injures vegetation is known as a phytotoxicant.

Injury to foliage may become visible in a short time and take the form of necrotic lesions (dead tissue) or it can develop slowly and become manifest as a yellowing or chlorosis of the leaf. There may be a reduction in growth of various portions of a plant or a loss in reproductive parts or in yield. Plants may be killed outright but they usually do not succumb until they have suffered injury perennially.

Injury may not be visible externally occurring subcellularly in cell membranes and chloroplasts (plant organelles where photosynthesis takes place). The plants may suffer physiologically due to an upset in the rate of photosynthesis, respiration or transpiration.

The symptoms of injury caused by phytotoxicants can be very similar to those of injuries caused by disease, insects, adverse weather, poor nutrition or mismanagement. All suspected cases require careful diagnosis by specialists.

The protection of plants from the adverse effects of aerial phytotoxicants cannot be carried out in exactly the same manner as is possible with disease-causing, organic reproductive bodies. A pollution-diseased plant cannot infect another plant; thus there is no need for a quarantine or for eradication of the affected plants. In certain instances, sprays and dusts have protected plants from air pollution injury. The development of resistant varieties holds some promise. The best control method, however, is to reduce the concentrations of noxious pollutants at their sources.

<u>Soiling and Property Damage</u>

One of the first material effects of air pollution is the soiling of clothing, buildings and properties. Air pollution has a direct influence on the cost of cleaning and laundering, the marketability of merchandise and the cleaning of buildings. It is responsible for considerable economic loss.

Property damage is usually of a cumulative nature. It tends to shorten the durability of materials exposed to the atmosphere. It is generally caused by the interaction of contaminants with the surface or protective coatings of materials.

Typical effects are metal corrosion, stone and masonry deterioration excessive cracking of rubber tires and damaged automobile paintwork.

Health Effects

Effects on human health have been most dramatic during so-called air pollution "episodes." These are fortunately rare. They occur when stagnant weather conditions allow a concentration of air pollutants to build up over a period of several days. At such times, people with severe chronic respiratory disease are greatly affected and many excess deaths can occur.

Serious pollution episodes have occurred in various parts of the world including the Meuse Valley of Belgium; Donora, Pennsylvania; New York City; London, England. Of these, the Donora and London episodes provide particularly dramatic evidence of the effects of air pollution.

In Donora, an industrial community located in a deep valley 30 miles south of Pittsburgh, thousands of people became ill, several hundred were hospitalized and 20 died when air pollutants from mills, smelters and acid plants accumulated during a calm period of weather in October, 1948 and did not disperse for four days.

In London, a much more serious episode, perhaps the worst in history, occurred in December, 1952. Again, during calm weather, air pollution became so concentrated that 4,000 deaths resulted from various respiratory diseases both during and after the episode.

The effect of day-to-day exposure to lower concentrations of air pollution is very difficult to assess. Some individuals are relatively susceptible, others less so. On the whole, people who live in industrial centres have an increased chance of getting certain diseases of the respiratory system.

Some forms of air pollution are more annoying than harmful. This is true of many unpleasant odors. Where the main source of pollution is the automobile, the air may cause the eyes to tear and the throat to be irritated without having any apparent lasting effect. Much research is still required to determine the real long term effects of exposure to polluted air.

Meteorology and Air Pollution

Meteorological factors greatly effect the amount of pollution present in the atmosphere. Temperature and solar radiation, by their influence on the amount of space heating required, affect the quantities of pollutant emitted. Sunshine is required for the photochemical production of oxidants that form smog.

Wind velocity, turbulence and stability affect the transport, dilution and dispersion of pollutants. Rainfall has a scavenging effect by washing out particles in the atmosphere. Finally, humidity is a frequent and important factor in determining the effect of pollutant concentrations on property, vegetation and health.

Meteorological parameters having the most important influence on the diffusion of pollutants in the atmosphere are wind direction and speed, turbulence, temperature and stability.

Wind

Wind is air in motion in three dimensions. Only the horizontal component, however, is usually considered in terms of direction and speed.

Wind direction indicates direction of travel of pollutants. It is a very important factor in predicting the air pollution potential of an area in which the principal pollutant sources are high stack emitters located close together. Wind direction is less important where low level emitters (low smoke stacks, automobiles etc.) cause most of the pollution.

Expected persistence of wind direction, related to topographic features and location of receptors, must also be considered both when forecasting air pollution potential and selecting sites for plants. Topographical features such as valleys cause winds to persist in certain directions at much greater frequencies than others. Obviously, large industries should not be located in such areas.

Wind speed determines the travel time of pollutants from a source to a receptor. Wind speed also has a dilution effect. Pollutant concentrations downwind from ground level sources are inversely proportional to wind speed.

This dilution effect is not true for hot emissions from high stack sources. In these instances, an increase in wind speed lowers the plume rise, thus tending (up to a point) to increase ground level concentrations. There is a "critical wind speed" for each stack design at which concentrations downstream reach a maximum.

Turbulence

High frequency fluctuations in the wind are known as turbulence and they occur both vertically and horizontally. These random motions

are responsible for the movement and diffusion of pollutants about the mean wind path.

Mechanical turbulence is caused by roughness of terrain -- trees, shrubs, buildings, etc. Thermal turbulence is due to the earth's surface being heated by the sun. Thermal eddies develop as the air, heating up at lower levels first, becomes less dense and rises.

Temperature

The temperature of the lower region of the atmosphere (surface to 2 km.) can either decrease or increase with height depending on the character of the underlying surface and the radiation at the surface. During the day, temperature usually decreases with height. As a result, the warmer air near to the ground and the pollutants emitted into it rise and disperse high into the atmosphere. Concentrations of pollutants in the lower layers of the atmosphere are relatively low.

When the reverse occurs and temperature increases with height, a temperature inversion is said to exist. An inversion inhibits the rise and dispersion of pollutants emitted in the atmosphere. Thus, when pollutants are emitted near the ground during an inversion, they remain and cause high concentrations to develop.

The Automobile and Air Pollution

The automobile is a major source of air pollution. In addition to carbon dioxide and water vapour, its exhaust emissions contain carbon monoxide, oxides of nitrogen, unburned hydrocarbons and lead.

Automotive pollutants result from the incomplete burning of fuel. When there is sufficient oxygen, hydrocarbon fuel is completely converted into carbon dioxide and water vapor. Incomplete combustion also produces carbon monoxide, hydrocarbons and oxides of nitrogen.

Incomplete combustion can occur for various reasons -- poor mixing of air and fuel, short combustion time, quenching of the combustion process near a cool chamber wall, dead space where the combustion flame can not penetrate.

Some of these problems can be reduced or eliminated by fine tuning of the carburetor and timing mechanism, by heating the air or fuel prior to mixing, or replacing the standard carburetor with a fuel injection system.

Crankcase emissions are eliminated by using a PCV (positive crankcase ventilation) valve that feeds crankcase vapors back to the air intake system to be burned in the combustion chamber. Gasoline evaporating through either the fuel tank breather tube or carburetor can be greatly reduced by terminating such tubes and other outlets with an activated charcoal filter that absorbs escaping vapors.

A catalytic muffler containing certain types of catalysts can be used to oxidize toxic gases in the exhaust. Due to the poisoning effect that lead has on the catalyst, however, the system can only be used with gaseous fuels, diesel fuel or unleaded gasoline.

Possible alternatives to the internal combustion engine are an electric power source, a modified steam engine and the gas turbine. Of special interest at present is the gasoline-electric hybrid that can be run on either gasoline or electric power.

Air Pollution Control In Ontario

Action against air pollution in Ontario began, as in most other jurisdictions, at the municipal level with the passing of local by-laws restricting smoke emissions.

In 1955, the Ontario government appointed a select committee to study the problem of air pollution and its control. As a result of the committee's report, the province passed its first Air Pollution Control Act in 1958. It delegated the control of air pollution to municipalities but widened the scope considerably to provide for the control of all sources of air pollution.

Actual provincial involvement under the 1958 legislation was purely advisory. In 1963, however, the Act was amended to give the province a more direct role. It undertook the approval of new sources of industrial air pollution, instituted a training program for municipal inspectors and established a program of financial assistance.

Attempts to stimulate air pollution control activity at the municipal level proved largely unsuccessful. Only four municipalities employed full-time staff. During the middle 1960's, it became readily apparent that serious headway could only be made by a centralized authority.

The province assumed full responsibility for the control of air pollution with the passing of the Air Pollution Control Act, 1967. The Act became effective January 2, 1968, and the Air Pollution Control Service of the Department of Health was named enforcement agency. In 1969, the Service was transferred to the Department of Energy and Resources Management Branch and renamed the Air Management Branch.

Scope of Air Pollution Control Act, 1967

Under the Act, the Ontario Government, through the Minister of Energy and Resources Management and the Air Management Branch, possesses broad powers allowing it to:

1. conduct air quality and meteorological studies and monitoring programs.

2. establish acceptable air quality levels.

3. inspect and regulate all sources of air pollution.

4. order, after investigation, the discontinuance of the discharge of any air contaminant. This action is reserved for unusual cases where such a discharge creates an immediate and serious danger to public health, and where a delay in following the usual procedures under the Act would prejudicially affect the public.

5. initiate legal action for violation of either a regulation made under the Act, or of a Minister's Order issued to correct a pollution condition. Maximum fine for an individual is $2,000; for a corporation, $5,000 on first conviction and $10,000 on second conviction. Each day that a violation occurs constitutes a separate offence.

Numerous regulations have been made under the Act. Of special importance are those regulations that established an air pollution index, standards for emitted contaminants, criteria for desirable ambient air quality, standards governing the sulphur content of fuels sold in Metropolitan Toronto and air pollution emission standards for motor vehicles, ferrous foundries and asphalt paving plants.

Non-legislated guidelines include criteria for the design and operation of incinerators and conical wood waste burners and a suggested code of practice covering the establishment of livestock buildings and the disposal of animal wastes.

Controlling Stationary Sources of Air Pollution

Prior to the 1967 Act, new industrial sources of air pollution, as already mentioned, had been subject to pre-construction government approval since 1963. In January, 1968, all new stationary sources of air pollution became subject to such approval.

At the same time, surveys were undertaken across the province to locate and assess existing sources of air pollution for which abatement programs began to be developed. As of April, 1971, most large and many smaller stationary sources of air pollution in Ontario have had or are about to have abatement programs established by which their polluting emissions are being either eliminated or reduced to acceptable levels.

Controlling Mobile Sources of Air Pollution

Mobile sources present a different control problem. Motor vehicles (automobiles, trucks, buses) come under provincial jurisdiction; ships, trains and aircraft do not.

Controls for certain classes of motor vehicles were brought into force at the beginning of the 1969 model year. Based upon regulations adopted first in California and later for all of the United States, they have been broadened in scope and made more stringent each successive year.

All aspects of ship, train and aircraft operation come under federal jurisdiction. The Air Management Branch can and does, however, enforce existing federal provisions concerning air pollution from these sources.

Smoke emissions from ships in Canadian waters are regulated under the Canada Shipping Act. Smoke emissions from locomotives and other railway property are regulated by Canada General Order O-26 issued by

the Board of Transport Commissioners for Canada. No regulations have been developed to control aircraft exhausts.

Limiting Air Contaminant Emissions: Design Standards

When the emission of an air contaminant cannot be entirely prevented from a new stationary source of air pollution or eliminated from an existing one, its amount can still be limited to a level that will not be harmful to either humans, animals, vegetation or property.

This is done by applying what are known as design standards to a source. It involves (1) calculating what the subsequent concentration of an emitted contaminant will be at point of contact with an object that could be adversely affected by it, and (2) comparing that concentration with the standard or maximum concentration allowed for the contaminant. If the calculated concentration is too high, modifications become necessary to reduce the amount of contaminant that is being or will be emitted at the source.

In certain instances, when there is no practical method of sufficiently reducing the contaminant at source, a tall stack will be permitted to disperse it over a wider area, thereby reducing ground level concentrations. Dispersion, however, is considered an interim measure only. The goal is elimination of pollutants at their source.

The point of contact mentioned above is referred to as the "point of impingement". It can occur at ground level itself or above ground (e.g., the side of a building). Concentration figures at point of impingement are averages calculated for periods of 30 minutes. The maximum concentration allowed for a given contaminant is well below that at which adverse effects would actually occur.

Maximum allowable concentrations at point of impingement have been established for 20 different contaminants: ammonia, beryllium, bromine, cadmium oxide, carbon bisulphide, carbon monoxide, chlorine, dustfall, fluorides, hydrogen chloride, hydrogen cyanide, hydrogen sulphide, iron, lead, lime, nitric acid, nitrogen oxides, silver, sulphur dioxide, suspended particulate matter. Tentative standards are set when necessary for other contaminants. They are incorporated into regulations when their validity has been fully established.

The maximum allowable concentration of sulphur dioxide at point of impingement is 0.3 parts per one million parts of air by volume averaged over a period of 30 minutes. The maximum allowable concentration of suspended particulate matter at point of impingement is 100 micrograms per cubic metre of air averaged over a period of 30 minutes.

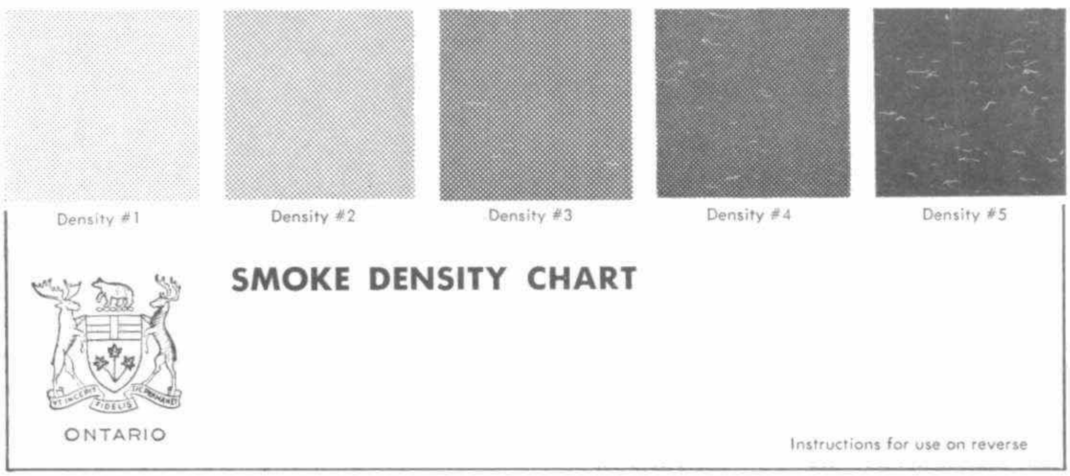
The calculation of a contaminant's concentration at a given point away from its source is a complex procedure beginning with a full evaluation of the equipment and processes involved to determine the contaminant's emission rate to the atmosphere (usually through a stack). When the emission rate is known, the concentration at point of impingement can be calculated. The physical and chemical details of the emission itself, as well as the topography, micro-meteorology and land usuage of the receptor area, are all important factors.

Emission Standards

Emission standards, like design standards, specifically indicate amounts of contaminants permitted to enter the atmosphere. Design standards are applied to individual stationary sources. Emission standards are developed for groups of like or identical sources such as automobiles.

Present Ontario automobile regulations incorporate exhaust emission standards for carbon monoxide and hydrocarbons. A similar standard governing the emission of oxides of nitrogen will come into force for the 1973 model year.

Smoke Density Chart



Smoke control is enforced by means of visual observation using a smoke density chart. Number 2 density (40 per cent black) is permitted for not more than 4 minutes in a half-hour period. When starting a new fire, number 3 density (60 per cent black) is permitted for 3 minutes in a 15-minute period. At all other times, the smoke density must not be greater than number 1 (20 per cent black). In cases of equipment failure, permission may be granted to exceed the limitations.

Official use of the chart is restricted to properly trained provincial government officers.

Air Quality Criteria

The major goal of air management in Ontario is the steady improvement of ambient air quality across the province, i.e., the reduction of air contaminant concentrations to desirable levels. Criteria for desirable air quality have been established under the Air Pollution Act for 15 different contaminants.

The criteria for sulphur dioxide are: 0.25 parts per million (p.p.m.) parts of air by volume averaged over a period of one hour;

0.10 p.p.m. averaged over 24 hours; 0.02 p.p.m. averaged over one year.

The criteria for suspended particulate matter are: 90 micrograms per cubic metre of air averaged over a period of 24 hours; a geometric mean of 60 micrograms per cubic metre for a period of one year.

These values are considered as objectives or goals and are used to assess existing air quality, evaluate progress and predicate abatement strategies.

Organization of the Air Management Branch

For administrative purposes, the Air Management Branch has divided the province into seven regions. Each is headed by a regional engineer and sub-divided into districts staffed by qualified engineers and inspectors. Offices are located in 15 cities across the province: Toronto, Hamilton, Peterborough, Welland, Waterloo, London, Windsor, Sarnia, Barrie, Oakville, Kingston, Ottawa, North Bay, Sudbury and Thunder Bay. Head office is in Toronto.

The number of districts and the personnel assigned to them are dependent upon economic activity, population and complexity of local air pollution problems. Total staff numbers approximately 225, excluding central administration personnel. The professional staff consists of 59 engineers, 25 scientists, 9 engineering assistants, 38 technicians and 61 inspectors.

The Air Management Branch contains six operating sections: Abatement, Approvals and Criteria, Air Quality and Meteorology, Automotive Emission Control, Phytotoxicology, Laboratory.

The Abatement Section investigates air pollution complaints; records and collects evidence to institute legal action against polluters; initiates and helps develop abatement programs, and keeps check on programs to see that they are functioning efficiently.

The development of an abatement program begins with a complete emission survey of the operations concerned. Surveys may be informal to assist a company in determining the nature, cause and extent of emissions as a step toward corrective action. They may also be formalized as a comprehensive survey under Section 83 of the Environmental Protection Act, 1971, which may be followed by the issue of a Control Order by the Director of the Air Management Branch. The Order is a legal document and failure to comply can result in prosecution.

A person to whom an Order of the Director is directed may, within fifteen days, request a hearing by the Environmental Appeal Board. The Board consists of representatives from the engineering, medical, urban planning, industrial, agricultural and labour fields. The Board may confirm, alter or revoke the Order. Provision is also made for a right of appeal, after the Board's decision has been made known, to the county court and to the Minister of the Environment.

The Approvals and Criteria Section evaluates the efficiency of proposed air pollution control methods, provides technological support for abatement field officers and establishes criteria for acceptable air quality levels.

Anyone planning to construct a new potential source of air pollution or modify an existing source in Ontario must first obtain a certificate of approval through the section. Failure to do so may result in necessary alterations if an unapproved facility is subsequently found to be in violation of the Air Pollution Control Act, 1967, or its regulations.

Certificates of approval are required for all industrial processes, large fuel burning installations, incinerators, and all commercial and institutional establishments emitting contaminants to the outdoor atmosphere.

Exempt are space heating installations for residential buildings housing three families or less and commercial establishments containing less than 35,000 cubic feet of space. However, corrective action can still be taken under the Air Pollution Control Act if air pollution complaints are received about such sources.

The Air Quality and Meteorology Section is primarily responsible for measuring air quality in Ontario. It also conducts applied research in the air pollution field and helps establish ambient air quality criteria.

The continuous monitoring of air pollutants and meteorological conditions in localized areas is done through a network of about 900 instruments spread across the province. Data is telemetered to Toronto for analysis and the calculation of air pollution indexes.

Pollutants monitored continuously are sulphur dioxide, dust particles, carbon monoxide, hydrocarbons, oxides of nitrogen, hydrogen sulphide, ozone and fluorides. Other contaminants measured on a spot sampling basis include lead, mercury, calcium, iron, magnesium, manganese, zinc, nickel, copper, nitrates, phosphates and sulphates.

The section was responsible for the development of a computerized mathematical air quality model for Metropolitan Toronto. The model consists of an information system containing pertinent facts about pollution sources, a wind generation routine for processing meteorological data and a simulation model by which climatic conditions and sources and amounts of pollution can be related to provide indications of actual air quality.

The model enables the Air Management Branch to evaluate different abatement strategies for existing pollution sources and predict changes in air quality due to both the construction of new sources and the implementation of new regulations (e.g., those governing automotive exhaust emissions). Similar models are being developed for other areas of the province.

The Automotive Emission Control Section works to reduce air pollution caused by automobiles, trucks and buses. Regulations governing emissions from automobiles went into effect at the beginning of the 1969 model year. As a result, 1970 automobiles produce only 30 percent of the emissions that come from 1968 models. 1975 automobiles will produce only five to ten per cent of 1968 emission levels.

Heavy duty gasoline and diesel powered vehicles have also been covered by regulations since the beginning of 1970. The section is working closely with the Automotive Transport Association of Ontario in an attempt to reduce excessive emissions from diesel trucks and buses. It is also conducting research into the adoption of anti-pollution devices for older uncontrolled motor vehicles.

The section operates two mobile test laboratories to carry out spot checks on 1969 and newer model cars. These checks indicate whether their pollution control devices are functioning efficiently or have been tampered with or removed. Maximum fine for tampering or removal is $100.00.

The Phytotoxicology Section is responsible for determining the degree and extent of air pollution injury to all types of vegetation throughout Ontario. It investigates complaints of economic loss to determine whether injury to plant growth is caused by air pollutants or by other harmful agents such as disease, insects, adverse weather, poor nutrition or mismanagement.

After making an assessment, the section prepares a report which goes to both the complainant and the owner or operator of the air pollution source allegedly responsible for the injury. If the parties concerned cannot reach an agreement privately, they may call on a Board of Negotiation to intervene. If no satisfactory settlement can be reached, court action may follow.

The section maintains a close surveillance of vegetation in areas of concern throughout Ontario. Ecological studies keep it informed of increasing or decreasing vegetation effects in the vicinity of existing pollution sources. Baseline studies are conducted in agricultural or forested areas before new major pollution sources become operational to determine pre-pollution endemic conditions.

The section also maintains specially-designed controlled environment facilities (growth chambers and greenhouse) to study the effects of air pollutants on vegetation. Experiments are conducted to supplement field investigations, to screen resistant plant species, and to determine air quality criteria for the protection of agriculture and forestry.

The Laboratory Section provides a chemical analytical service to the Air Management Branch. It conducts analysis of air-borne contaminants, vegetation and soil samples, and certain other materials (metal plates, pieces of rubber and nylon) that have been left exposed to the atmosphere for varying lengths of time. Each is analyzed for the effects of corrosive elements.

The need for analysis and measurement has accompanied the development of extensive sampling networks throughout the province and the increased investigation of source emissions and complaints directed to the Branch.

Research is conducted into ways of improving sampling and analysis techniques in order to expand the knowledge spectrum of air pollutants. This research is especially directed at certain harmful contaminants that are difficult or impossible to analyze by conventional monitoring methods.

Inter-Departmental Co-Operation

The work of air pollution control often involves the participation of other provincial government departments and agencies. Common programs and investigations are co-ordinated by the Pollution Control Advisory Committee. The Committee is chaired by the Deputy Minister of Energy and Resources Management. Six departments are represented -- Mines and Northern Affairs, Lands and Forest, Agriculture and Food, Health, Municipal Affairs, Energy and Resources Management -- as well as the Ontario Water Resources Commission.

The Department of Health provides advisory services through a physician on loan to the Air Management Branch. He advises on ambient air quality criteria and investigates specific complaints of health effects. In addition, the Department of Health conducts epidemiological studies.

International Co-Operation

Ontario directly shares an international boundary with three American states. Because of the problems of transboundary air pollution, the provincial government is involved in various programs at both federal and province-state levels, much of it through the International Joint Commission. Established by the Canadian and American governments, the Commission does not have any regulatory powers but does conduct comprehensive investigations and recommend corrective actions.

Various state and provincial personnel become involved in the Commission's work. A recent example is a study completed in January, 1971, on air pollution problems in the Sarnia-Port Huron and Windsor-Detroit areas of Ontario and Michigan.

Air Pollution Index and Alert System

A significant aspect of Ontario's air management program is its Air Pollution Index and Alert System. The Index was established to give warning of, and to prevent the adverse effects of air pollution build-ups during prolonged periods of stagnant weather. It went into operation in Toronto in March, 1970; Hamilton in June, 1970; Sudbury in January, 1971; Windsor in March, 1971. The Index network is gradually being expanded to other major centres in the province.

The Index is based upon continuous measurements of sulphur dioxide and suspended particulate matter, Ontario's two major air

pollutants. Both have been found in high concentrations during severe air pollution episodes in other parts of the world and extensive data is available relating severity of health effects to degree of pollution as measured by their presence.

The structure of the index is a numerical scale beginning at 0. Readings below 32 are considered acceptable, indicating concentrations of sulphur dioxide and suspended particulate matter that should have little or no effect on human health. At 58, people with chronic respiratory disease may be affected. At 100, prolonged conditions could have mild effects on healthy people and serious effects on those with severe cardiac or respiratory disease.

The alert system functions at four index levels -- 32 (Advisory Level), 50 (First Alert), 75 (Second Alert), 100 (Air Pollution Episode Threshold Level).

At 32, if meteorological conditions are expected to remain unfavorable for at least six more hours, owners of major sources of air pollution sources may be advised to prepare for possible curtailment of their operations. At 50 and 75, under continuing, adverse meteorological conditions, they can be ordered to curtail them.

At 100, the Minister of Energy and Resources Management can order all sources of air pollution not essential to public health or safety to cease operations. A reading of 100, however, is unlikely to be reached becuase of previous provisions for curtailment at lower index levels.

The highest Toronto index reading, based upon available figures, would have occurred in Toronto between November 30 and December 4, 1962. The index would have reached a peak of 155 during the evening of December 1, and 125 during the early morning hours of December 4. The average reading over this four day period would have been 95.

The most significant aspect of this particular pollution build-up was a dense smog which caused that year's Grey Cup game to be played on two separate days. There was no recorded incresase, however, in hospital admissions of people with respiratory ailments during this period, an indication of the margin of safety built into the index.

Financial Assistance For Air Pollution Control Programs

There are several ways in which companies, institutions and municipalities can obtain financial assistance for the installation of air pollution control equipment.

They can apply for grants up to the amount of the provincial sales tax paid on the equipment, obtain Ontario Development Corporation loans, receive certain federal sales tax exemptions and take advantage of accelerated capital cost allowances.

Grants are also available through the Department of Energy and Resources Management to universities and other organizations for research and training of persons in the field of air pollution, and to

municipalities to assist in the administration and enforcement of air pollution by-laws. The 1970 research budget was $318,000.

Suggested Code for Livestock Buildings and Animal Wastes

"A Suggested Code of Practice for the Establishment of New Livestock Buildings, Renovation or Expansion of Existing Buildings, and Disposal of Animal Wastes" was prepared in 1970 by the Departments of Energy and Resources Management, Agriculture and Food.

The Code is only a recommended guideline, but one that Ontario farmers are being urged to follow. Because of a population increase in farming areas and more intensive livestock and poultry production, greater animal wastes are being produced, often without adequate provision for disposal. As a result, serious odor problems have developed, affecting both rural and urban people.

The Code provides fair and satisfactory measures for dealing with the problem. Key measures stress the need for enough land on which to dispose of wastes, sufficient waste storage capacity (e.g. underground tanks), and adequate distances between livestock and poultry buildings and neighbouring dwellings.

Farmers following the Code can invite inspection of their premises. If they are considered to be operating within its provisions they receive a letter of approbation to that effect.

In Conclusion

Air pollution remains a serious problem in certain parts of Ontario. A considerable amount of progress has been and is being made, however, and major improvements are forthcoming. Within the next few years, virtually all sources of air pollution in the province will be under control, emitting either no contaminants at all or contaminants at acceptable levels of concentration. When this degree of control has been achieved, pollution build-ups will occur only during prolonged periods of stagnant weather.

In the meantime, everyone can do something about air pollution by:

1. burning wasteless fuels.
2. keeping cars well tuned.
3. turning off car engines when forced to wait for more than a minute or two.
4. walking or using public transportation rather than a car.
5. using hand lawn mowers.
6. not burning rubbish and leaves in open fires.

Open fires are a particular problem. A large percentage of the Branch's inspection time is taken up with their control -- time that could be put to much better use regulating more serious problems. In this area alone, therefore, there are significant opportunities for individuals to contribute to the control of air pollution. Much could be accomplished if everyone took advantage of them.

First Printing: April 1971

Second Printing: May 1973
(Revised)

Ontario

Ministry
of the
Environment

Published by
Information Services Branch
135 St. Clair Avenue West
Toronto, Ontario
M4V 1P5